



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Application of:

Inventors : Alexander Leybovich
Serial No. : 10/624,384
Filed : July 22, 2003
Title : Method and Apparatus for Deposition
Of Low-K Dielectric Materials
Examiner : Steven H. VerSteeg
Art Unit : 1753
Docket No. : 020324 227P2
Customer No.: 33,805

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Sir:

DECLARATION UNDER 37 C.F.R. 1.132

I, Alexander Leybovich, residing at 4433 Knoll Crest Dr. Grove City, Ohio 43123, make the following

Declaration:

I am a U.S. Citizen.

I hold the degree of MS in Electrophysics with specialization in Physics of Gaseous Discharges and Vacuum Technology from Leningrad Polytechnic Institute, Leningrad, USSR (currently St-Petersburg Technical University, St-Petersburg, Russia). I have also completed four-year postgraduate school with specialization in thin film technology.

I am currently group leader at Tosoh SMD, Inc. and perform work related to Sputter Science R&D and R&D in NDT for sputter targets.

I am the inventor of four U.S. Patents in the field of thin film technology and sputter target NDT. I am also the inventor of eight foreign patents (author's certificates) in the field of thin film technology (PVD & dry etching), electrochemistry, and sensor technology. I have a number of scientific publications in J. Vac. Sci. Technol. related to physics of sputtering plasma.

I am the inventor of the above-identified patent application and am familiar with the practice

of performing physical vapor deposition of low-K dielectric materials according to its teachings.

According to the invention, a cloud of sputtered particles is formed. To form a cloud of sputtered particles a sputter particle, thermalization of the sputtered particles needs to occur.

The thermalization of the sputtered particles occurs when the gas density in the transport region is high enough to provide intense elastic collisions between sputtered particles and atoms of residual gas. This can be achieved by increasing the gas pressure to the level when mean free path of elastic collisions becomes small relative to length of transport region, providing intensive kinetic energy and momentum exchange between sputtered particles and atoms of the residual gas. These collisions create the isotropy in sputtered particle momentum and reduce its kinetic energy to a "cold" level.

The thermalization reduces the energy brought by depositing particles to the film.

I have read and am familiar with U.S. Patent 5,292,122 issued to Katsube et al. that I understand has been relied upon by the Examiner in rejecting the claims of the application.

The Katsube apparatus includes among other components a neutral beam generation means including one or plurality of individual generating means for irradiation, a target which is supported on a target base equipped with means for target rotation, a vacuum chamber for holding the target and target base, a substrate supported on substrate base equipped with driving mechanism and a temperature measurement means.

The Katsube method includes steps of ionizing Ar gas (with cold cathode) introduced into a reaction chamber at an Ar pressure of 3×10^{-5} Torr, accelerating the produced ions with an accelerating voltage in the range of 0.1 – 100 kV, and converting the ions produced into neutral atoms by passing them through an electronic atmosphere for neutralization. The target is irradiated with the high speed neutral atoms propagating in vacuum of 10^{-4} Torr or less, thereby sputtering the hydrophobic compound on the substrate.

To increase the sputter efficiency, the angle between beam and target surface is set between 15 & 60 degrees. The substrate is disposed normal to the target surface and has a parallel movement to provide homogeneity in growing film. The target is rotated to cool the target in order to prevent its decomposition.

In Embodiment 1 of the Katsume reference, the FAB gun 2 (Fig.1) irradiates the rotating target at point P using a beam propagating through open vacuum in the chamber with gas pressure of 3×10^{-5} Torr. Four different acceleration voltages are used (i.e., 4, 5, 6, 7 kV). The target table is brought into rotation to prevent target overheating. The sputtering rate is set to 100-370 A.

In Embodiment 3 of the Katsume reference, sputtering was carried out with revolution rate of the target 90 min/rotation and neutral beam acceleration voltage of FAB 2 to 4, 5, 6, 7, 8, 9, 10 kV.

In Embodiment 4 (Fig.6) of the Katsume reference, an atom beam gun 11 manufactured by Ion Tec Co., Ltd. is disposed in the vacuum chamber 10 along with the target base 12a and target 12 and substrate holder 13a with substrate 13. Argon is supplied directly into the gun through a dedicated line. The gun is operated under a max voltage of 10 kV, and max current of 10 mA. The atom beam gun 11 is supported by the armature and brackets providing adjustment of the shooting angle of the gun. Argon gas atoms directed into gun ionized by high voltage, and the ions thus generated are accelerated in the electric field and ion charges are neutralized by electronic atmosphere in the neighborhood of gun 11 thus generating high speed neutral ion beam. This beam bombards the target and sputtered particles are deposited on the wafer. The sputtered particles are ejected with cosine curve distribution affecting film uniformity, to improve the film uniformity substrate may be rotated. The atom beam gun 11 includes an ionizing chamber, such as cold cathode, an ion accelerating chamber and an ion neutralization mechanism. The beam emitted from the gun is desirably perfectly neutralized but several percent (less than 5%) of ions may remain in the beam

In Experiment 4 of the Katsume reference, the angle between the "Teflon" target and beam is set to 30 to 45 degrees. The vacuum chamber is evacuated to 2×10^{-4} Torr or below. The gun voltage is set to 8 kV and the target is rotated at the rate of 1 revolution per 30 min to prevent thermal decomposition.

In my opinion, the Katsume reference does not teach the formation of a cloud of sputtered particles and under the cited conditions, such a cloud could not form. The Katsume reference teaches the use of a relatively low residual gas pressure (density) of 3×10^{-5} Torr (Embodiment 1) to 2×10^{-4}

Torr (Experiment 4) with mean free path of elastic collisions in the range of tens of centimeters and extremely low sputter/deposition rate (reported by Katsube Fig. 8, Experiment 4). These criteria do not provide conditions for formation of a sputter particle cloud. At the gas pressure taught in the Katsube reference, every particle emitted by the target would reach the substrate practically without collision.

For this reason, the sputtered particles bring their original kinetic energy of several eV to the film, thereby heating the film. This energy is much higher than the energy of thermalized sputter particles. This seems to be a possible cause why the growing films in Katsube apparatus require cooling in spite of a very low deposition rate (See Fig. 8).

Much higher residual gas densities and sputtering rates are required to form a cloud of thermalized sputtered particles. However, it is not possible to increase the pressure in the transport area of the Katsube apparatus due to already very low deposition rate. Increasing the pressure will reduce the rate even more, almost to zero.

In summary, the formation of a cloud of sputter particles is not inherently taught by the Katsube reference, and having studied this reference, I do not believe that it anticipates or renders obvious the features as covered in the patent application.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon..

Signed:



Alexander Leybovich

Date:

